Examination

“Chemical Material Technology – Syntheses Techniques”

Date: February 13th, 2015 **Max. 50 Points**

Name, Given name: **Enrolment number:**

Please only use these sheets (you might also use the reverse)!

Task 1) (6 Points)

Solid State Reactions

a) Explain why reaction in the solid state take place only slowly in most cases! What can be done to speed up reaction rates? (2 Points)

b) Sketch the formation of the spinel $NiAl_2O_4$ from the cubic starting materials Al_2O_3 and NiO? (2 Points)

c) Name two factors which determine the speed (constants) of a solid state reaction! (2 Points)

Task 2) (6 Points)

Co-precipitation Reactions

a) Please name two advantages of co-precipitation routes for the synthesis of solid state compounds! (2 Points)

b) Describe the synthesis of the ferrimagnetic garnet $Y_3Fe_5O_{12}$ by using a co-precipitation process (starting materials shall be Y_2O_3 and Fe_2O_3)! (2 Points)

c) Explain the application of urea and urotropin for the homogeneous precipitation process! What is the advantage of the use of urotropin over urea? (2 Points)

Task 3) (6 Points)

Carbothermal Nitridation

Eu^{2+} doped silico nitrides are applied as red, yellow and green emitting luminescent materials in phosphor converted LEDs. For the synthesis of nitride hosts the carbothermal nitridation is widely applied. Balance the reaction equations for the synthesis of the following nitride compounds!

a) $SrCO_3 + Si_3N_4 + N_2 + C \rightarrow Sr_2Si_5N_8$ (1 Point)

b) $BaCO_3 + Y_2O_3 + SiO_2 + N_2 + C \rightarrow BaYSi_4N_7$ (1 Point)

c) $CaCO_3 + Al_2O_3 + Si_3N_4 + N_2 + C \rightarrow CaAlSiN_3$ (1 Point)

d) $SrCO_3 + SiO_2 + N_2 + C \rightarrow SrSiN_2$ (1 Point)

e) $La_2O_3 + SiO_2 + N_2 + C \rightarrow La_3Si_6N_{11}$ (1 Point)

f) $SrCO_3 + SiO_2 + N_2 + C \rightarrow SrSi_2N_2O_2$ (1 Point)

Task 4) (6 Points)

Synthesis by Fluxes

a) Name the two effects of fluxes to enhance the reaction rate! (2 Points)

b) What kind of fluxes are useful for the solid state synthesis of oxides and why? (2 Points)

c) What kind of fluxes are useful for the solid state synthesis of nitrides and why? (2 Points)

Task 5) (6 Points)

Synthesis of Nanoscale Inorganic Pigments

Describe the following chemical techniques for the preparation of nanoscale particles by using a respective example!

a) Polyol method (2 Points)

b) Microemulsion technique (2 Points)

c) Pechini method (2 Points)

Task 6) (6 Points)

Chemical Transport Reactions

a) Name three application areas of chemical transport reactions!

b) Balance the following chemical transport reactions!

$W + O_2 + I_2 \leftrightarrow$

$Ni + CO \leftrightarrow$

$Ti + I_2 \leftrightarrow$

Task 7) (6 Points)

Hydrothermal Synthesis

a) Sketch a reactor system for the hydrothermal growth of Quartz crystals (4 Points)

b) By which chemical measure one can enhance the speed of the hydrothermal growth of Quartz and Ruby crystals? (2 Points)

Task 8) (8 Points)

Luminescent Pigments

a) Many different kind of loss processes reducing the photoluminescence efficiency of luminescent pigments can occur during the absorption, energy transfer and the emission process. Give an example for a common loss process during all three steps of the energy flow! (3 Points)

b) By which technical measures one can improve the long-term stability of luminescent pigments? Give two examples! (2 Points)

c) A 100 g sample of $BaMgAl_{10}O_{17}$:Eu ($\rho(BaMgAl_{10}O_{17})$ = 3.8 g/cm^3), which consists of monodisperse spherical particles with a diameter of 5 µm shall be coated by MgO. Calculate the required amount of MgO to coat all particles by a dense and 50 nm thick coating layer (ρ(MgO) = 3.58 g/cm^3). How much $Mg(NO_3)_2$ is required as precursor for the $Mg(OH)_2$ precipitation? (3 Points)